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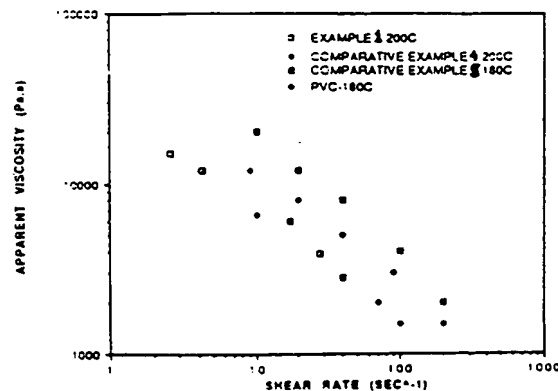
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(54) Non-halogenated flame-retardant resin composition and wires and cables coated therewith.

(57) A flame-retardant resin composition for electrical insulation and sheathing of wire and cables which has enhanced oil resistance and excellent processing characteristics, comprising (a) 100 parts by weight of a polyolefin polymer, (b) 50 to 200 parts by weight of a metal hydroxide or hydrated metal salt, (c) 3 to 20 parts by weight of a polyolefin based polymer or oligomer grafted or copolymerized with a vinyl bearing species, where polyolefin based polymer (c) differs from polyolefin polymer (a), and (d) 1 to 10 parts by weight of a silicone compound.

FIGURE 1. VISCOSITY VERSUS SHEAR RATE FOR RESIN COMPOSITIONS



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The present invention relates to a flame-retardant electrically insulating compound that does not evolve toxic or corrosive gases as it burns. Such compounds are especially suited for use as insulation or sheathing for electrical wires and cables.

High rise buildings, power stations, various industrial plants, transit systems, such as subways and ships, are especially vulnerable to fire hazard. Due to the large number of people and the limited exits found in such environments, severe loss of life can occur in the event of a fire. Furthermore, if large amounts of smoke are generated exits and exit routes are obscured, loss of life occurs which would have been avoided if no such smoke condition had prevailed and rapid evacuation had thus been possible.

Additionally, fire can spread along wire or cable, especially in duct systems. Smoke and the harmful gaseous ignition products of a fire or smoldering material can be transported through, for example, air conditioning systems or subway tunnels and cause health hazards in areas remote from the original point of ignition.

Corrosion obviously causes severe damage to equipment. A fire in a telephone exchange, for example, can cause loss of life of people not involved at the fire site, due to corrosion induced failure of telephone, alarm and control systems and the subsequent loss of ability to contact emergency services.

Thus, there is a need for insulation and sheathing materials for wires and cables that are self extinguishing and which do not evolve toxic or corrosive gases or large amounts of smoke. Furthermore, fungal attack can occur in the confined, damp conditions in which such wires and cables are installed, particularly in transit systems and ships.

Resin compositions which do not evolve toxic and corrosive gases and have anti-fungal properties are described in U.S. Patent No. 4,871,787.

A common problem which occurs with such resin compositions is that the incorporation of large amounts of metal hydroxides into polymeric materials has a deleterious effect on the tensile elongation of the resin compositions compared to the unmodified base polymers. Due to this low elongation, cracking and tearing of the insulation or sheath can take place during both installation and use.

A further effect is that the viscosity of such metal hydroxide loaded resin compositions is so high that they are very difficult to form into the final object. Slower extrusion rates and specialized high pressure equipment are required, especially when compared to flame retardant, low smoke compositions based on poly(vinyl chloride) polymers.

Thus, flame retardant commercial resin compositions known to the art which contain metal hydroxides generally compromise one or more of their properties to optimize one or more of the others. Such compromises could be avoided if it were possible to significantly reduce the amount of metal hydroxide present without reducing the flame retardancy of the resulting resin composition.

According to the present invention there is provided a flame-retardant, electrically insulating composition comprising (A) 100 parts by weight of a polyolefin (Polymer 1), (B) 50 to 200 parts by weight of metal hydroxide or a hydrated metal salt, (C) 3 to 20 parts by weight of a polyolefin polymer grafted or copolymerized with a vinyl containing species (Polymer 2) and (D) 1 to 10 parts by weight of a silicone containing material. Components (A) to (D) are essential components in accordance with the present invention.

At least 0.2 parts by weight of an amine compound and typical amounts, known to the art, of stabilizers and process aids can optionally be present.

The present invention has been accomplished on the basis of the finding that the desired properties are obtained as the result of increased flame-retardancy due to a novel synergy between a polyolefin polymer grafted or copolymerized with a vinyl containing species and a silicone material in a metal hydroxide or hydrated metal salt containing resin composition. This synergy holds if the resin composition is a thermoplastic or if it is crosslinked to form a thermoset material.

The resin compositions of the present invention exhibit those properties desired of a fire-retardant resin composition, viz., a high degree of flame-retardancy, good physical properties, superior tensile elongation, ease of fabrication and anti-fungal properties, and they contain significantly lower amounts of metal hydroxide(s) than those resin compositions known in the art.

A further advantage of the present compositions is that they possess an enhanced resistance to fluids such as oils and gasoline.

The resin composition of the present invention finds special use as electrical insulation and sheathing of electrical wires and cables, and the present invention is also directed to such a combination.

Examples of the polyolefin (Polymer 1) that can be used are polyethylene and ethylene copolymers with  $\alpha$ -olefins such as propylene, butene, hexene, octene and 4-methylpentene-1, polypropylene, ethylene propylene elastomers, ethylene vinyl acetate copolymers, ethylene methyl acrylate copolymers, ethylene methacrylate copolymers, ethylene ethyl acrylate copolymers, ethylene butyl acrylate copolymers.

ethylene vinyl silane copolymers and terpolymers of the preceding materials. Blends, whether physically mixed or produced during reaction, can also be used. The melt index of Polymer 1 should lie in the range of about 0.05 - about 200 dg/min, more preferably, about 0.1 to about 20 dg/min and most preferably 0.5 - 5 dg/min measured at 190 °C according to ASTM Method D 1238.

5 If ethylene copolymers or terpolymers are used as Polymer 1, the range of comonomer content (i.e., other than ethylene) can be 5% to 30% by weight based on total copolymer or terpolymer weight as Polymer 1. However, in consideration of such factors as heat distortion and mechanical strength, a comonomer content in the range of 5% to 20 % by weight is preferred, same basis.

Polymer 1 differs from Polymer 2, and serves as a matrix to carry the fire-retardant additive(s). Polymer 10 2 illustrates a flame retardancy in combination with the silicone containing material greater than that shown by Polymer 2 used without the silicone containing material in the resin composition of the present invention. Polymer 2 increases the fire-retardancy of the resin composition as a whole as compared to an otherwise identical resin composition without Polymer 2.

Polymer 1 cannot be replaced by Polymer 2 because tensile properties would be so reduced as to 15 make the resulting composition of no practical utility.

For Polymer 2, grafted materials as compared to copolymerized materials are preferred.

Polymer 1 provides physical strength to the resin composition of the present invention, e.g., excellent tensile elongation and Shore Hardness, so that the resin composition of the present invention exhibits not only both of such properties to a degree equal to or superior to the prior art, and in the resin composition 20 has flame retardancy equal to or greater than that of prior art polyolefin-based resin compositions and ease of processability greater than corresponding prior art polyolefin-based compositions, i.e., will exhibit an ease of processability equivalent to those encountered with typical polyvinyl chloride based compositions, so that the same are extrudable with a low extruder pressure and at normal rates.

The base polymer or oligomer (an oligomer is a very low molecular weight polymer) for grafting or 25 copolymerization with a vinyl bearing species to yield Polymer 2 can be any of the polyolefins, copolymers, terpolymers, or blends or mixtures thereof listed above for Polymer 1. Examples of the vinyl bearing species can be a vinyl hydroxy carboxylic acid, a vinyl carboxylic acid, a vinyl hydroxy dicarboxylic acid, a vinyl dicarboxylic acid, esters thereof and anhydrides thereof. It is contemplated that such acids which contain up to about 12 or more carbon atoms (in total) should prove potentially useful in the present 30 invention. Esters with 1 to 4 carbon atoms in the ester moiety, i.g., methyl to butyl acrylate, are also contemplated as potentially useful.

Specific examples of vinyl carboxylic acids and vinyl hydroxy carboxylic acids are acrylic acid and hydroxyacrylic acid, respectively. Specific examples of vinyl dicarboxylic acids are fumaric acid and maleic acid. A preferred anhydride is maleic anhydride.

35 The amount of the vinyl containing species grafted or copolymerized onto the base polymer to yield Polymer 2 is generally 0.1 to 20% by weight, more preferably 0.1 to 5% by weight, based on the weight of the base polymer. This range is especially applicable to the preferred vinyl containing species, maleic anhydride, and most especially when the maleic anhydride is grafted or copolymerized onto polyethylene or a polyethylene copolymer, a most preferred embodiment of the present invention.

40 The amount of Polymer 2 is 3-20 parts by weight per 100 parts by weight of Polymer 1, and preferably 7 to 15 parts by weight, same basis.

These ranges, of course, especially apply to the most preferred embodiment of the present invention just discussed, i.e., maleic anhydride (0.1 to 20%, more preferably 0.1 to 5% by weight) grafted or copolymerized onto polyethylene or a polyethylene copolymer.

45 Modification of Polymer 1 with Polymer 2 improves the compatibility of the metal hydroxide and Polymer 1 in the resulting resin composition, providing improved properties, most especially tensile properties.

In accordance with the present invention, a silicone material is used in an amount of 1 to 10 parts, more preferably 3 to 7 parts, by weight per 100 parts of Polymer 1.

50 Useful silicone containing materials can be characterized by the structure  $\{Si(R_1, R_2 - O)\}_n$  i.e., are organopolysiloxanes which can be liquids, gums or elastomeric solids, depending on the nature of  $R_1$ ,  $R_2$  and the molecular weight. ASTM has developed the following classifications for silicones as are useful in the present invention:

MQ -- methylsilicone;  
55 VMQ -- methylvinylsilicone;  
PMQ -- methylphenylsilicone; and  
PVMQ -- methylphenylvinylsilicone.

All such silicone materials can be used in the present invention. It is preferred that the polysiloxane be either a liquid or a gum and most preferably in the form of a gum, that is, a sticky, tacky-like material. Most preferred as a silicone material is poly(dimethyl siloxane) used in an amount of 1 to 10 parts by weight, more preferably 3 to 7 parts by weight, per 100 parts by weight of Polymer 1, which is a cyclic dimethylsiloxane which contains 6 to 15 repeating siloxane units.

The composition of the present invention further comprises 50 to 200 parts by weight of a metal hydroxide or a hydrated metal salt.

The metal hydroxides and hydrated metal salts that are suitable for use in the present invention have an average particle size of 0.1 - 30  $\mu\text{m}$ , preferably 0.5 - 15  $\mu\text{m}$ .

If a metal hydroxide or hydrated metal salt to be used has been surface-treated with a suitable compound such as a fatty acid, a silane compound or a titanate compound, it will be dispersed in the polymers used sufficiently uniformly to produce a composition that has improved processability in such applications as extrusion molding. Specific examples of such metal hydroxides and hydrated metal salts include aluminum hydroxide, magnesium hydroxide, basic magnesium carbonate (a typical hydrated metal salt), calcium hydroxide or hydrotalcite.

The amount of the metal hydroxide or hydrated metal salt to be incorporated must be in the range of 50 - 200 parts by weight per 100 parts per weight of Polymer 1 and most preferably 60-120 parts by weight, same basis. If this amount is less than 50 parts per weight, the desired flame resistance will not be imparted. If this amount exceeds 200 parts by weight, a reduction in extruding processability and mechanical strength will be brought about. The ranges are especially applicable to a magnesium hydroxide resin composition.

Typical surface treatment agents include fatty acid salts such as sodium stearate, fatty acids such as oleic acid, vinyl silanes such as vinyltriethoxysilane, and conventional titanates. Surface treatment is conducted in a conventional manner using conventional amounts, for example, an amount of about 0.1 wt% based on the weight of the metal hydroxide or hydrated metal salt.

The most preferred of such materials for use in the present invention is magnesium hydroxide, next preferred is aluminum hydroxide, and third preferred is calcium hydroxide. Magnesium hydroxide permits use of a higher extrusion temperature due to its relatively high decomposition temperature (about 350°C) as compared to aluminum hydroxide, which has a decomposition temperature of about 220°C. Calcium hydroxide is relatively soluble in water, and, thus, in wet environments can lead to problems. Mixtures can, of course, be used.

The amine compound optionally used in the present invention is a compound having at least one hydrogen atom in ammonia ( $\text{NH}_3$ ) replaced by a hydrocarbon group R, and there are three kinds of amines, that is  $\text{RH}_2$ ,  $\text{R}_2\text{NH}$  AND  $\text{R}_3\text{N}$ . The present inventor has confirmed by experimentation (U.S. Patent 4,871,787) that improved anti-fungal action can be imparted by the addition of an amine compound.

Specific examples of the amine compound that can be used in the present invention include: bis-(phenyl-propylidene)-4,4'-diphenylamine; N-isopropyl-N'-phenyl-p-phenylenediamine; a polymer of 2,2,4-trimethyl-1,2-dihydroquinoline; 2,5-ditert-butylhydroquinone; 2-mercaptobenzimidazole and 2-mercaptomethyl-benzimidazole. Most preferred are mercapthbenzothiazole or a polymer of 2,2,4-trimethyl-1,2-dihydroquinoline.

The amount of amine optionally incorporated should be not less than 0.2 parts by weight per 100 parts by weight of the polyolefin. If this amount is less than 0.2 parts by weight, the desired anti-fungal action will not be attained. While there is no particular upper limit for this content, about 20 parts by weight could be given as a guide figure.

In addition to the essential ingredients earlier described and the optional amine, the composition may optionally contain carbon black, lubricants, process aids, antioxidants, softening agents and dispersants, all of which are conventional in the art.

The resin composition of the present invention may or may not be crosslinkable. If it is to be crosslinkable, organic peroxides as typified by dicumyl peroxide and 3-bis(tert-butylperoxylisopropyl)-benzene can advantageously be used as curing agents, e.g., in an amount of about 1-4 parts by weight per 100 parts by weight of Polymer 1. Such curing agents may be used in combination with curing assistants such as sulfur, ethylene dimethacrylate, diallyl phthalate and p-quinone dioxime. Crosslinking of the composition may be accomplished by irradiation by electron beams and, in such a case, generally, reactive monomers such as trimethylolpropane trimethacrylate and triallyl isocyanurate are added as curing assistants in conventional amounts. Usually a crosslinked resin composition herein will show a gel content of at least about 70% (decalin extraction test).

The following Examples and Comparative Examples are provided to further illustrate the present invention but are in no way to be construed as limiting.

## In the Examples:

POLYMER 1 is an ethylene ethyl acrylate copolymer, melt index 0.8 dg/min, ethyl acrylate content 15% based on total weight of Polymer 1.

POLYMER 2 is a linear low density polyethylene density 0.915 g/cm<sup>3</sup>, melt index 30 dg/min grafted with 1% maleic anhydride based on total weight of Polymer 2.

SILICONE is a cyclic dimethylsiloxane gum containing 6 to 15 repeating siloxane units and having a molecular weight of about 1,000 and a viscosity of  $1 \times 10^6$  centipoise measured at 25 °C.

FUNGICIDE is a polymer of 2,2,4-trimethyl-1,2-dihydroquinoline.

ANTIOXIDANT is 4,4'-thiobis-(6-tert-butyl-3-methylphenol).

METAL HYDROXIDE is magnesium hydroxide of a particle size 1  $\mu$ m surface treated or coated with about .1% sodium stearate based on the weight of magnesium hydroxide.

CARBON BLACK is a furnace black of particle size 30 - 35 m $\mu$  and BET surface area 75 m<sup>2</sup>/g.

PROCESS AID is stearic acid.

CROSSLINKING AGENT is dicumyl peroxide.

The non-crosslinkable compositions were mixed on a six-inch roll mill at 170 °C. The crosslinkable formulation was similarly mixed at 120 °C.

Plaque samples for evaluation were prepared for all compositions by hot pressing the roll mill compositions at 170 °C.

The flame retardant properties of the resin compositions have been assessed by the method of limiting oxygen index (LOI) which has wide acceptance by specifying bodies as a measure of flame retardancy of materials.

LOI as determined by ASTM D 2863 is defined as the percentage of oxygen that it is necessary to add to a nitrogen atmosphere such that ignition of a test sample of a resin composition exposed to this mixed atmosphere will ignite.

Since air contains 21% oxygen a sample of resin composition which ignites in air will have an LOI of 21. Such a resin composition is obviously not flame retardant.

The degree to which the atmosphere has to be enriched with oxygen in excess of 21% to support ignition of a sample of a resin composition is therefore a measure of the flame retardancy of the resin composition.

The composition of Examples 1 and 2 and Comparative Examples 1 to 3 and their LOI values are shown in Table 1 below.

Comparative Example 1 is a typical resin composition as described in U.S. Patent No.4,871,787.

Comparative Example 2 is Comparative Example 1 to which 10 parts by weight of Polymer 2 has been added. The LOI of Comparative Example 2 is 1.5 units lower than that of Comparative Example 1.

Comparative Example 3 is Comparative Example 1 to which 5 parts by weight of a silicone has been added. The LOI of Comparative Example 3 is 9.9 units higher than that of Comparative Example 1.

Example 1 is Comparative Example 1 to which both Polymer 2 and silicone have been added. On the basis of the LOI values obtained for Comparative Examples 1 and 2, it would be expected that the LOI of Example 1 would be approximately 8 units higher than that of Comparative Example 1. In fact the LOI of Example 1 is 14.1 units higher than that of Comparative Example 1.

Example 2 is Example 1 crosslinked with dicumyl peroxide. It shows the same flame retardancy as Example 1.

Thus the addition of both Polymer 2 and silicone has an unexpected, novel, synergistic effect on the flame retardancy of metal hydroxide filled resin compositions.

TABLE 1: RESIN COMPOSITIONS

COMPOUND	COMPARATIVE EXAMPLE 1 parts by weight	COMPARATIVE EXAMPLE 2 parts by weight	COMPARATIVE EXAMPLE 3 parts by weight	EXAMPLE 1 parts by weight	EXAMPLE 2 parts by weight
COMPONENT					
POLYMER 1	100	100	100	100	100
METAL HYDROXIDE	80	80	80	80	80
POLYMER 2	--	10	--	10	10
CARBON BLACK	10	10	10	10	10
SILICONE	--	--	5	5	5
FUNGICIDE	0.5	0.5	0.5	0.5	0.5
ANTIOXIDANT	0.5	0.5	0.5	0.5	0.5
PROCESS AID	0.5	0.5	0.5	0.5	0.5
CROSSLINKING AGENT	--	--	--	--	1.7

LOI (%)	29.3-30.2	27.5-29.0	39.1-40.3	43.3-44.5	43.2-44.4
INCREMENT IN LOI	--	MINUS 1.5	9.9	14.1	14.0

Comparative Examples 4 through 6 now presented are commercially available polyolefin based, metal hydroxide filled compositions which are widely used for the wire and cable applications described in the background of the present specification. Comparative Example 6 is used crosslinked with dicumyl peroxide.

From the density of these materials it can be readily calculated that they contain 150 to 200 parts by weight of metal hydroxide as compared to Example 1 which contains only 80 parts by weight.

For the synergy claimed for Example 1 to be real and thus meet the objectives of the invention, it is required that Example 1 should, when compared to Comparative Examples 4 and 5, and that Example 2 should, when compared to Comparative Example 6, show the following properties.

At least equivalent LOI value;

Comparable Tear Strength and Durometer Hardness;

At least double the Tensile Elongation; and

Comparable retention of Tensile Elongation after aging.

As is shown in Tables 2 and 3 below these requirements are clearly met.

TABLE 2

PROPERTIES OF THERMOPLASTIC RESIN COMPOSITIONS			
PROPERTIES OF RESIN COMPOSITIONS	EXAMPLE 1	COMPARATIVE EXAMPLE 4	COMPARATIVE EXAMPLE 5
DENSITY @ 20° C ASTM D 1505	1.27	1.50	1.57
LIMITING OXYGEN INDEX ASTM D 2863	44	41	36
TENSILE ELONGATION (%) ASTM D 638	503	190	127
HEAT AGING 7 DAYS @ 100° C	88	72	70
%RETENTION TENSILE ELONGATION			
TEAR STRENGTH (LB/IN) ASTM D 470	60	53	29
DUROMETER HARDNESS (SHORE A)	95	95	95

TABLE 3

PROPERTIES OF-CROSSLINKED RESIN COMPOSITIONS			
PROPERTIES OF RESIN COMPOSITIONS		EXAMPLE 2	COMPARATIVE EXAMPLE 6
DENSITY @ 20 °C ASTM D 1505		1.27	1.52
LIMITING OXYGEN INDEX ASTM D 2863		43	40
TENSILE ELONGATION (%) ASTM D 638		450	200
HEAT AGING 7 DAYS @ 100 °C %RETENTION TENSILE ELONGATION		100	100
TEAR STRENGTH (LB/IN) ASTM D 470		60	45
DUROMETER HARDNESS (SHORE A)		95	95

A further objective of the invention was to provide a material which shows enhanced oil resistance. Table 4 below shows that Example 1 is clearly superior (where TS = tensile strength and TE = tensile elongation).

TABLE 4: OIL RESISTANCE OF RESIN COMPOSITIONS

PROPERTY	COMPARATIVE EXAMPLE 1	EXAMPLE 1	COMPARATIVE EXAMPLE 4	COMPARATIVE EXAMPLE 5
FLUID RESISTANCE 18 hrs. @ 70 °C % TS RETENTION / % TE RETENTION ASTM #2 OIL	87/96	97/110	78/137	78/127
FLUID RESISTANCE 24 hrs. @ 50 °C % TS RETENTION / % TE RETENTION				
HYDRAULIC FLUID 5606	60/90	70/107	58/142	48/134
HYDRAULIC FLUID 17872	70/90	90/110	84/100	75/104
DIESEL OIL 18884	41/93	64/103	41/156	39/170
LUBRICATING OIL 24467	64/95	87/114	70/137	69/123
LUBRICATING OIL 23699	77/94	97/110	92/106	85/102
FLUID RESISTANCE 24 hrs. @ 20 °C % TS RETENTION / % TE RETENTION	87/100	101/106	87/153	82/102
METHANOL	45/96	68/96	63/184	56/117
GASOLINE				

A further objective of the invention was to provide a material of reduced viscosity to provide ease of processing. Polyolefin resin compositions such as Comparative Examples 1 and 2 require special equipment and techniques for wire and cable extrusion due to their high viscosity. On the other hand, flame retardant poly(vinyl chloride) based resin compositions are known for their ease of extrusion using standard equipment and techniques.

The sole Figure of the accompanying drawing shows viscosity shear rate data for Example 1, Comparative Examples 4 and 5 and PVC, a standard poly(vinyl chloride) based flame retardant resin composition, measured at their typical wire extrusion temperatures (200 °C for Example 1 and Comparative Example 4 and 180 °C for Comparative Example 5 and PVC).

Clearly Example 1 is markedly less viscous by at least a factor of two at all shear rates, compared to Comparative Examples 4 and 5 and is comparable to PVC and thus will exhibit the same easy processing characteristics of the latter.

#### Claims

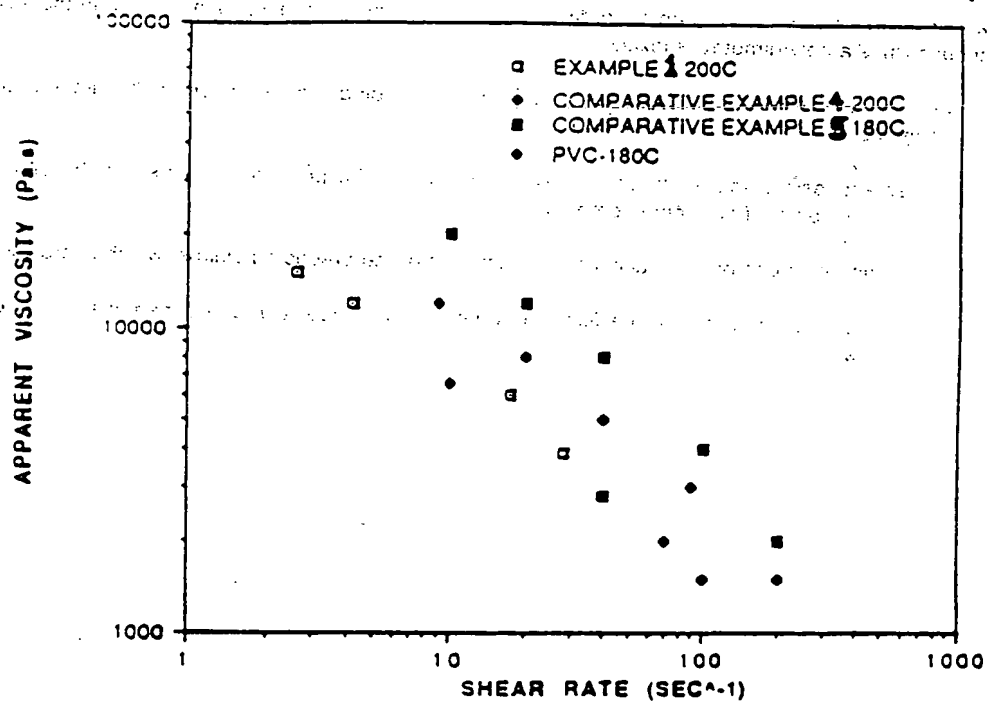
1. A flame-retardant resin composition for electrical insulation and sheathing of wire and cables which has enhanced oil resistance and excellent processing characteristics, comprising (a) 100 parts by weight of

a polyolefin polymer, (b) 50 to 200 parts by weight of a metal hydroxide or hydrated metal salt, (c) 3 to 20 parts by weight of a polyolefin based polymer or oligomer grafted or copolymerized with a vinyl bearing species, which polyolefin (c) differs from polyolefin (a), and (d) 1 to 10 parts by weight of a silicone compound.

- 5 2. A flame-retardant resin composition according to claim 1, wherein polyolefin (a) is an ethylene copolymer, the copolymer content of which is 5% to 30% by weight.
- 10 3. A flame-retardant resin composition according to claim 1 or 2, wherein the metal hydroxide is magnesium hydroxide which is used in an amount of 60 to 120 parts by weight.
- 15 4. A flame-retardant resin composition according to any one of the preceding claims, wherein polyolefin (c) is polyethylene or a polyethylene copolymer which is grafted or copolymerized with maleic anhydride, the maleic anhydride content being 0.1% to 5% by weight.
- 20 5. A flame-retardant resin composition, wherein the amount of polyolefin (c) is 7 to 15 parts by weight.
6. A flame-retardant resin composition according to any one of the preceding claims, wherein the silicone compound (d) is a poly(dimethyl siloxane).
- 25 7. A flame-retardant resin according to any one of the preceding claims, wherein the amount of the silicone compound (d) is 3 to 7 parts by weight.
8. A flame-retardant resin composition according to any one of the preceding claims, which contains at least 0.2 parts by weight of an amine compound.
- 30 9. A flame-retardant resin composition according to any one of the preceding claims, which is crosslinked.
10. Electrical wires or cables coated with a flame-retardant resin composition as defined in any one of the preceding claims.



FIGURE 1: VISCOSITY VERSUS SHEAR RATE FOR RESIN COMPOSITIONS





European Patent  
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# EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 92300792.6
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 5)
X;Y	US - A - 5 002 996 (OKUDA et al.) * Column 3, line 3 - column 6, line 11; examples *	1-5, 7, 9, 10; 6, 8	H 01 B 3/44 C 08 K 3/22
Y	US - A - 4 731 406 (ITOH et al.) * Abstract; column 6, lines 18-37 *	6	
D, Y	US - A - 4 871 787 (YAMAMOTO et al.) * Abstract *	8	
A	US - A - 4 801 639 (HOSHI et al.) * Abstract *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 5)
			H 01 B 3/00 C 08 K
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 21-10-1992	Examiner KUTZELNIGG
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

FORM 1503 (01.82) (P0401)